In adults, what is the association between intake of sugar-sweetened beverages and energy intake?

Conclusion

Limited evidence shows that intake of sugar-sweetened beverages is linked to higher energy intake in adults.

Grade: Limited

Overall strength of the available supporting evidence: Strong; Moderate; Limited; Expert Opinion Only; Grade not assignable For additional information regarding how to interpret grades, click here.

Evidence Summary Overview

To answer this question the Committee reviewed one meta-analysis (Vartanian, 2007) and four trials (Flood, 2006; Reid, 2007; Soenen, 2007, Stookey et al, 2007) published since 1990. Vartanian et al (2007) conducted a meta-analysis that examined the association between soft drink consumption and various health outcomes, including energy intake. It should be noted that this analysis included some unpublished data as well as cross-sectional studies. However, they conducted separate analyses based on study design and outcomes. Of the 88 studies in the review, three longitudinal studies and 11 experimental studies examined the relationship between soft drink consumption and energy intake in adults. Although effect size was small, the authors concluded that there was a clear positive association between soft drink intake and energy intake.

Two additional primary studies also support a relationship between the intake of sugar-sweetened beverages (SSB) and increased energy intake. Flood et al (2006) examined the impact of beverage type (cola, diet cola or water) and size (12 or 18 fluid ounces) on intake at an ad libitum lunch. Energy intake from food consumed at lunch did not differ across conditions. However, when the energy from beverages was added to the energy consumed from food, mean total energy intake at lunch was greater when regular cola was served as compared to the other beverages, regardless of portion size.

Reid et al (2007) compared the effects of supplementary soft drinks sweetened with sucrose or aspartame added to the diet over four weeks on dietary intake in normal-weight women. Participants consumed four 250ml bottles of drink per day. Sucrose supplements provided 430kcal per day and aspartame supplements provided less than 20kcal per day. For those consuming the sucrose drink, daily energy intake was higher during the intervention phase than at baseline; women consuming the SSB consumed about 200kcal more energy each day.

Stookey et al (2007) compared four weight loss diets and predicted that replacing sweetened caloric beverages with water would save 200kcal per day over 12 months. Although weight loss might be expected due to lower energy intake, change in body weight was not analyzed.

Soenen and Westerterp-Platenga (2007) examined the satiating effects of high fructose corn syrup (HFCS) and sucrose in comparison with milk and a diet drink. In this trial, participants completed four test sessions that included an ad libitum meal served after one of four beverages: One containing sucrose, one HFCS, one milk and one a diet drink. All four drinks were isovolumetric (800ml). The energy drinks were isocaloric. Test meal energy intake was lower after consumption of pre-loads containing sucrose or HFCS or milk (with no differences between the energy-containing pre-loads) compared to the diet drink pre-load. Total energy intake (pre-load + meal) with the energy-containing pre-loads was significantly higher than total energy intake with the diet drink pre-load. During the meal, energy intake from the beverage was partly compensated for. However, compensation for energy intake from the pre-loads containing sucrose, HFCS or milk did not differ significantly and ranged from 30% to 45%. This study indicated that although energy intake was higher following the drinks sweetened with HFCS and sucrose compared to a diet drink pre-load, energy intakes were not different than the milk pre-load, indicating that theadded sugar did not have a unique effect on energy intake.

Evidence summary paragraphs:

Vartanian et al, 2007 (positive quality), a systematic review and meta-analysis, examined the association between soft drink consumption and nutrition and health outcomes. MEDLINE and PsycINFO were searched to find articles that examined the association between soft drink consumption and nutrition and health outcomes. Key words used included “soft drink,” “soda” and “sweetened beverage” along with four primary outcomes (energy intake, body weight, milk intake and calcium intake) and two secondary outcomes (nutrition and health). Additional articles were identified by searching each article’s reference section and the Web of Science database. Finally, authors were contacted to request unpublished or in-press work. Eighty-eight studies were included in the meta-analysis; approximately 30 comparisons were available for soft drinks and energy intake or body weight in adults. Analysis of primary outcomes revealed a significant degree of heterogeneity of effect sizes, and thus, studies were separated according to research design. Average energy intake effect sizes for adults:

- Overall: R=0.28 (95% CI: 0.27, 0.30; P<0.0056; N=19)
- Cross-sectional: R=0.28 (95% CI: 0.26, 0.30; P<0.0056; N=2)
- Longitudinal: R=0.29 (95% CI: 0.27, 0.31; P<0.0056; N=3)
- Experimental (short): R=0.22 (95% CI: 0.15, 0.29; NS; N=11).

The authors concluded that they found clear associations of soft drink intake with increased energy intake and body weight. Further, they stated that recommendations to reduce population soft drink consumption are strongly supported by the available science.

Reid et al, 2007 (positive quality) compared the effects of supplementary soft drinks added to the diet over four weeks on dietary intake, mood and body mass index (BMI) in normal-weight women (N=133; age 20 to 55 years; BMI 17 to 24.9kg/m^2). The study took place over five weeks, including one week of baseline data collection followed by four weeks of drink supplementation. Drinks contained either sucrose or aspartame. Participants were either informed that they were receiving sugary drinks or ‘diet’ drinks, meaning that half were correctly informed about the drink content and half misinformed. In addition, participants were recruited according to whether they were or were not currently watching their weight. This resulted in a 2 x 2 x 2 design (sucrose vs. aspartame, drinks labeled sugar vs. labeled aspartame or diet, watcher vs. non-watcher). Subjects received four 250ml bottles of drink per day in uniform bottles with the labeling manipulated. Each week of the four-week intervention, participants were given one week’s supply of 28 test drinks and were instructed to drink the agreed amount each day at the specified times (11.00, 14.00, 18.00 and 20.00 hours). Sucrose supplements provided 1,800kJ per day and aspartame supplements provided 67kJ per day. Food intake was measured with a seven-day diary during each week of the five-week study.

Height and weight were measured by study personnel. There were no significant effects of restraint (watching or non-watching) status on any of the experimental analyses. For this reason, results were presented without 'watching' as a factor. For those consuming the sucrose drink, energy intake was higher at week one: (t (67df) = 6.44; $P<0.001$) and at week four than at baseline (t (67df) = 3.82; $P<0.001$) and week one and week four did not differ (t (67df) = 1.81; $P=0.075$). Women in the sucrose group consumed about 800kJ more energy per day; the supplements contained 1,800kJ. Mean body weight at baseline was 61.35±8.37kg. There was a marginal effect of drink on body weight (F (10•20, 1.86) = 4.509; $P<0.05$), with more women who received the sucrose drink gaining some weight during the study and more women receiving aspartame losing weight. There was a non-significant trend for those receiving sucrose to gain weight. The authors concluded that compensation was only partial for added sucrose, so were sucrose to be added to the diet, some weight gain might result in normal-weight individuals.

Flood et al, 2006 (positive quality), a randomized crossover trial, examined the impact of increasing beverage portion size on beverage and food intake. A component of the study design was to compare beverage type (cola, diet cola or water). Participants were 33 adults (55% female; age 19 to 30 years) who consumed lunch in the laboratory once a week for six weeks, for a total of six test sessions. On each test day, a standard breakfast was served in order to ensure a consistent level of hunger across sessions. At each lunch, the same foods were served, but the beverage served was varied in type (cola, diet cola or water) and portion size (12 or 18 fl oz). The regular soda provided 150 and 225 kcal for the small and large servings, respectively. The order of experimental conditions was randomized across subjects. At all meals, subjects could eat ad libitum from the amount of food and beverage that was served. All foods and beverages were weighed prior to being served to subjects, and reweighed after the subjects had finished eating, to determine the amount of food and beverage consumed. Energy intake from food consumed at lunch did not differ significantly across conditions. However, when the energy from beverages was added to the energy consumed from food, mean total energy intake at lunch was significantly greater when regular cola was served, regardless of portion size ($P<0.001$). Therefore, even though subjects consumed more energy from the caloric beverage than the non-caloric beverages, they did not compensate for this additional energy by reducing food intake. The authors concluded that when a caloric beverage was consumed with a meal, food intake was not reduced and energy from the beverage added on to energy from food, resulting in a significant increase in total energy consumed at a meal; further, replacing caloric beverages with low-calorie or non-caloric beverages can be an effective strategy for decreasing energy intake.

Soenen and Westerterp-Platenga, 2007 (positive quality) examined the satiating effects of HFCS and sucrose in comparison with milk and a diet drink. Participants were 40 adults (50% female; BMI 22.4±2.1kg/m^2). The four beverages were as follows: A beverage containing sucrose, one containing HFCS, one containing milk and a diet drink. All four drinks were isovolumetric (800 ml). The energy drinks were isoenergetic and provided 1.5mJ. The diet drink had an energy content of 0.2mJ. A within-subjects design was used, with each subject returning for four separate test days one or more weeks apart. An ad libitum meal (granola cereal and yogurt) was served 50 minutes after participants completed the pre-load; all foods were pre-weighed at the time of serving, and plate waste was collected and weighed. Test meal energy intake was significantly lower after consumption of pre-loads containing sucrose or HFCS or the milk pre-load (with no differences between the energy-containing pre-loads) than after the diet pre-load ($P<0.05$). Total energy intake (pre-load + meal) with the energy-containing pre-loads was significantly higher than total energy intake with the diet pre-load ($P<0.01$). Therefore, during the meal, energy intake was only partly compensated for. Compensation for energy intake from the pre-loads containing sucrose, HFCS, or milk did not differ significantly and ranged from 30% to 45%. The authors concluded that there were no differences in energy balance consequences after HFCS, sucrose, or milk pre-loads.

Stookey et al, 2007 (positive-quality) evaluated change in beverage pattern, specifically, drinking water as an alternative to sweetened caloric beverages (SCBs), in a secondary analysis of data from the Stanford A-TO-Z intervention. The Stanford A-TO-Z study was a clinical weight loss trial that randomized overweight pre-menopausal women to four weight loss diets: Dr. Atkins' New Diet Revolution, The Zone: A Dietary Roadmap, The LEARN Program for Weight Management 2000, or Eat More, Weigh Less by Dr. Dean Ornish. Participants included in analyses were 118 overweight women (25 to 50 years) who regularly consumed SCBs (12oz or more a day) at baseline. At baseline and two, six and 12 months, mean daily beverage intake (SCBs, drinking water, non-caloric diet beverages and nutritious caloric beverages), food composition (macronutrient, water and fiber content) and total energy intake were estimated using three 24-hour diet recalls. Beverage intake was expressed in relative terms (percentage of beverages). In fixed-effects models that controlled for total beverage intake, non-caloric and nutritious caloric beverage intake (percentage of beverages), food composition and energy expenditure [metabolic equivalent (MET)], replacing SCBs with drinking water was associated with significant decreases in total energy intake that were sustained over time. The caloric deficit attributable to replacing SCBs with water was not negated by compensatory increases in other food or beverages. Replacing all SCBs with drinking water was associated with a predicted mean decrease in total energy of 200kcal per day over 12 months. The authors concluded that replacing SCBs with drinking water can help lower total energy intake in overweight consumers of SCBs motivated to diet.

Study	Meta-Analysis	Authors Conclusion
***Vartanian, 2007** Class: M Quality rating: (+)	Meta-analysis examined the association between soft drink consumption and nutrition and health outcomes [88 original studies [energy intake: three longitudinal and 11 experimental studies with adults)].	(+) Clear association of soft drink intake with ↑ energy intake observed.

*Review included cross-sectional studies.

Study	Design: Trials	Sugar-Sweetened Beverage (SSB)	Comparison	Time	Support a Positive Relationship Between SSB and Energy Intake?
Reid, 2007 Class: A Quality rating: (+)	Parallel-arm trial with four soft drinks added to daily diet.	Regular soft drink.	Diet soft drink.	Four weeks	Yes

Flood, 2006 Class: A Quality rating:	Randomized crossover trial with ad libitum beverage and lunch.	Cola	• Diet cola • Water	One day (test meal)	Yes
Soenen, 2007 Class: A Quality rating:	Crossover trial with pre-load followed by test meal.	• Sucrose beverage • HFCS beverage	• Milk • Diet drink	One day (test meal)	No (higher energy intake with added sugar, but same energy intake as with milk drink)
Stookey, 2007 Class: B Quality rating:	Secondary analysis of data from Stanford A-TO-Z intervention examining drinking water as alternative to sweetened-caloric beverages (SCB).	SCB.	Water	Two, six and 12 months	Yes

Research Design and Implementation Rating Summary
For a summary of the Research Design and Implementation Rating results, click here.

Worksheets

Flood JE, Roe LS, Rolls BJ. The effect of increased beverage portion size on energy intake at a meal. *J Am Diet Assoc.* 2006 Dec; 106(12): 1,984-1,990.

Reid M, Hammersley R, Hill AJ, Skidmore P. Long-term dietary compensation for added sugar: Effects of supplementary sucrose drinks over a four-week period. *Br J Nutr.* 2007 Jan; 97(1): 193-203.

Soenen S, Westerterp-Plantenga MS. No differences in satiety or energy intake after high-fructose corn syrup, sucrose, or milk preloads. *Am J Clin Nutr.* 2007;86(6):1586-94.

Stookey JD, Constant F, Gardner CD, Popkin BM. Replacing sweetened caloric beverages with drinking water is associated with lower energy intake. *Obesity (Silver Spring)*. 2007 Dec;15(12):3013-22.

Vartanian LR, Schwartz MB, Brownell KD. Effects of soft drink consumption on nutrition and health: a systematic review and meta-analysis. *Am J Public Health*. 2007 Apr;97(4):667-75. Epub 2007 Feb 28.